Work-In-Progress: Re-Engineering Engineering: A Collaborative Inquiry Toward a Solidarity Engineering-Focused Future

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Abstract

What is the purpose of engineering? Who does engineering? Who is engineering done for? As engineering is increasingly associated with cutting edge technology and innovative advances in complex and/or large scale systems, these are questions that merit reflection. These trends tend to disproportionately benefit those in wealthy sectors of society. Simultaneously, those with the least economic wealth are often negatively impacted. But, engineering doesn't have to continue along this path. It is instructive to reflect on the fact that engineering encompasses technologies and designs that have served much of the human population for ages. Engineering to meet basic human needs, such as working with the natural world toward sustainable food gathering practices, building homes and infrastructure, maintaining health, expressing humanity through the arts, and experiencing joy has been a major trend throughout human history. At the same time, engineering has also been used for destructive purposes, including the development of tools and processes that subjugate and inflict violence upon humans, other living things, and the environment. A critical juncture in the path that engineering has taken occurred during the 2nd Western Industrial Revolution from the mid 1800's to the early 1900's. During this time, enterprises for capitalist accumulation of wealth and power came to dominate the field of engineering and engineers became wedded to the interests of corporate capitalism. Today the legacy of this shift persists. While there continue to be engineers organizing and pursuing engineering for the wellbeing of humanity and the planet, pathways towards this work within our larger systems of engineering training and practice are unclear and involve higher levels of personal risk.

Our aim is to develop a vision of engineering that seeks to meet the needs of the planet and its inhabitants. Critical to this vision is the embrace of practices that center the participation of all people, particularly those from historically marginalized groups. The process of doing so must be authentic and inclusive. Using a framework of Solidarity Engineering, this paper lays out the authors' process of critical reflection on the dominant practices and structures that need to change in engineering education and the engineering profession. As engineering education faculty, students, and support practitioners, we are engaging in a collaborative inquiry methodology to examine engineering education programs, recruitment, and curricula, and engineering career pathways to identify key practices that hinder learning about and working towards Solidarity Engineering. This work-in-progress presents a broad outline of work we are undertaking to explore what we call the "re-engineering" of both engineering education and of potential career pathways. Through our work, we hope to identify a broad set of solidarity-focused examples and methods. Further, we hope this paper inspires a larger conversation about how the engineering profession can reframe its ways of engaging within the world to promote a movement toward Solidarity Engineering that contributes to an ethic of care, love, equity, and justice among people and planet.

Keywords: *Solidarity Engineering, Ethics of Care, Love, Social Justice, Equity, Sustainability, Capitalism, Militarism, Collaborative Inquiry, Engineering Pathways*

Introduction

> "We live in a world in which a tree is worth more, financially, dead than alive, in a world in which a whale is worth more dead than alive. For so long as our economy works in that way and corporations go unregulated, they're going to continue to destroy trees, to kill whales, to mine the earth, and to continue to pull oil out of the ground, even though we know it is destroying the planet and we know that it's going to leave a worse world for future generations. … now we're the tree, we're the whale."
>
> - Justin Rosenstein in *The Social Dilemma* [1]

The word "engineer" is derived from the Latin root word "*ingenium,*" which refers to "innate qualities, ability; inborn character" [2]. To engineer means to contrive or devise. Through an ontological lens, every invention and technological advancement has inevitably shaped and reshaped the world. At the heart of this practice is the modern-day engineer whose role is to bridge the gap between what is and what could be. And so, engineers function as the manifestors of the designed world. The praxis of engineering is giving birth to the seen, felt, and tangible in the world, as contrived in scientific understanding and theoretical knowledge.

It follows then, that a question should be asked: what world are engineers taught to build and who has access to this world? Ontological frameworks demonstrate that "the world we design is, in turn, designing us" [5]. So whose world is the engineer commissioned to build? On a hopeful note, several engineering organizations emphasize the fact that engineering can be used for the benefit of humanity [6]. Nevertheless, it is critical to acknowledge that engineering has been and continues to be used in ways that are harmful to human beings, other living organisms, and the environment [7]. The fundamental structure and culture of engineering is currently dominated by militarism, capitalism, racism, and cisheteropatriarchy.

Engineering in Western countries, within a formal capacity, was never established separately from the military. In fact, the first formal engineering educational program in the United States was founded at West Point Military Academy [8]. Exorbitant amounts of research funding continue to tie the direction of academic training to the interests of the military [9]. Nearly half (44% in 2017) of all federal research dollars in science in engineering are directed toward defense related work. Career centers at universities in the United States are legally required to provide enrolled student contact information to the military for purposes of employment [10]. Furthermore, career centers offer generous support for the recruitment of students to military contractors. Today, the US Department of Defense employs more than 100,000 engineers [11], likely making it the largest employer of engineers in the world.

Similarly, engineering has perpetuated various forms of violent practices towards disenfranchised communities and the natural environment. Racism (specifically, white supremacy) and cisheteropatriarchal violence are deeply embedded in and reproduced by engineering educational systems [12]. STEM remains a white, masculine space established upon

a totalizing, apolitical, zero-point epistemology that functions aggressively across racial difference. Engineering students and faculty are socialized to legitimize a white habitus of scholarly praxis and trained to think through a disciplinary "common sense" of institutional whiteness [13-14].

While militarism, racism, and cisheteropatriarchy have been a continuous presence in the practice of engineering in Western industrialized countries, the domination of corporate capitalism is a more recent development. During the Second Western Industrial Revolution, engineers became increasingly tied to corporate capitalism [15]. By the 1950's, the social responsibility of engineers was codified through the engineering societies' "codes of ethics," with a primary focus on the idea that "the engineer should consider the protection of a client's or employer's interest as his first professional obligation" [16, p. 39], demonstrating a hyper-focus on capitalistic production. Learning to be an engineer is also a capitalistic enterprise, as even public educational institutions require the exchange of money for knowledge.

Employment opportunities in engineering are mainly in the private sector. Much of the work done by these engineers is aimed at addressing the interests of the small segment of the population who are able to pay high prices for engineering services. Engineering that does take place in the public sector generally occurs through large governmental institutions at the national, state, and local level. Large federal institutions that employ engineers include sectors of the US military, the US Army Corp of Engineers, and agencies such as the Department of Energy and NASA. Smaller local government agencies that employ engineers include city engineering departments, water treatment facilities, and public works departments. While some sectors of the public may benefit from public engineering work, it often excludes or brings harm to marginalized communities and their environments, as Indigenous water protectors and environmental justice leaders have articulated [17-18].

This Work in Progress paper looks at steps that can be taken to "re-engineer" engineering, from its current destructive focus as described above, to prioritizing people and communities lacking in wealth and power. Our work is based on engineering and engineering education in the US, but the state of engineering in other parts of the world also merits similar critical analysis.

Conceptual Framework

> "Human beings in communion liberate each other." [19, p. 129]

Through our shared love for the work of Paulo Freire [19], bell hooks [20], and Myles Horton [21], we consider ourselves students and practitioners of liberatory pedagogies. Liberatory pedagogies recognize that education can never be neutral, that it always occurs in context and in relation to power structures. Liberatory pedagogies meet people where they are at and focus on fostering critical inquiry and collective actualization through methods of *praxis*, which consist of action and reflection. Each participant's presence is acknowledged and the expertise of their lived experience is recognized. Therefore, everyone participates as both a learner and a teacher. This educational approach has been characterized as "Popular Education," or "Pop Ed" [22-23].

We recognize that we are not alone in this struggle to liberate ourselves and our students. Others in the academy [e.g., 24] as well as outside it [e.g., 23] share our desire for liberation.

In particular, we are engaging in the praxis of re-engineering engineering through the framework of Solidarity Engineering (SE) [6]. Drawing on principles of liberative pedagogies, SE prioritizes relationships within communities and personal connections over products and theoretical designs. At its core is respect, care, and appreciation for all participants, and a sharing of agency and power regardless of academic qualifications. It uses the praxis of love, wherein community partners are valued for their perspectives and their knowledge, especially non-technical, non-conventional knowledge that is usually looked down upon. SE draws inspiration from the wisdom of various cultures' understanding of unconditional love, compassion, universal kinship, and connectedness, such as the Yankunytjatjara concept of Kaynini [25] and ubuntu in South Africa [26]. Finally, SE focuses on transformative change, not reformative perpetuation of oppressive structures, and aims to break down power dynamics both within and outside of educational spaces.

Positionality

Our critique is grounded in our social positionality and reflections on ways in which we do and do not have access to power and agency within engineering and academic spaces. We come together from a wide variety of life experiences and with social identities that shape our individual and collective perspectives. We are diverse in race, economic class, gender/sexuality, ability, and culture. We grew up in urban, small town, and rural communities, and with US, South Asian, and Caribbean roots. Within academia, we hold a variety of positions--lecturer, undergraduate student, recent graduate, doctoral student, Diversity Equity and Inclusion staff, and tenure-track faculty--skewed toward the lower power levels within academic hierarchical structures. Our diverse backgrounds help us see and critique US-based engineering systems from outside perspectives. Still, we critique these systems today generally from an insider perspective and, in many ways, are complicit with the way they operate now. From a global viewpoint, we have benefited from relatively privileged positions in terms of economic and educational opportunity.

Critique of the System

Absence of diversity in the engineering profession is one symptom indicating a lack of health in the culture and its processes for recruiting, educating, and retaining engineers. Despite decades of efforts to increase diverse participation in engineering in the US, women and People of Color are still drastically underrepresented. For example, according to a National Science Board report, the percent of engineering degrees awarded to women has hovered at 20% since the turn of the millenia and actually declined half a percentage point between 2000 and 2015 [27]. Additionally, the percentage of bachelor's degrees in science and engineering awarded to Black, Latinx, and Indigenous students in 2015 was only between half and two-thirds what would be expected based on population demographics. Workforce participation of women and minorities in science and engineering professions is even lower [28]. This stagnation has led to questions about the cultural and logistical conditions that limit broader participation. Barriers have been extensively explored in the literature, but proposed solutions tend to focus on changing the individual to fit better in the system (e.g., "lean in", executive coaching, meditation) rather than questioning the

overarching system that makes these barriers so difficult to overcome. Additionally, studies show that Black, Latinx [29], and female students [30] tend to identify having positive social benefit as a significant objective for their career paths. However, there are few opportunities currently for engineers to engage in research or employment that is of direct benefit to people in communities, particularly in marginalized communities without access to power in the current socio-political context.

Therefore, the structural and cultural problems inherent to our engineering and engineering education systems are rooted far deeper than analyses of participation commonly acknowledge. They also contribute to the persistent lack of diversity. The capitalistic, militaristic, racist, and cisheteropatriarchal structure and culture of engineering manifests itself in a variety of methodologies, ideologies, and epistemologies. We choose to highlight a few here that we view as symptoms of a deeply problematic culture and structure and then evaluate them through the lens of SE. Our view of these symptoms as emblematic is shaped by our individual and collective positionality. Some of the symptoms are commonly cited critiques of engineering education and professional culture, while others are critiques that we have synthesized through our discussions of SE and our reflections on our experiences in engineering.

Some well-cited aspects of mainstream engineering education and professional culture:

- *Exclusivity*: Currently, the vast majority of the human population does not have a role in determining the areas of research and development in engineering [31]. Knowledge construction within the field is exclusive, due to financial barriers to entering the academy and conducting research. Rising inequities and exploding student loan debt, which disproportionately affect women and people of color [32] only exacerbate the issue further. Exclusivity expressly violates the SE concept of sharing agency and power.
- *A/de-politization*: Engineering focuses largely on de-contextualized problem solving. Being ‘apolitical’ is considered vital, so even inherently political issues are stripped of that context [33]. Grading focuses on technical skill, rather than critical thinking. A/de-politization is antithetical to the SE foci on relationship-building and the push for transformative change.
- *Social-Technical Dualism*: Mainstream engineering ideology views the technical and social aspects of design and problem solving as distinctly separate. A false hierarchy is introduced in which the most technical tasks are also the most valued and highly compensated [12]. Dualism violates SE values of connectedness and respect and appreciation for varied ways of knowing and being.
- *Objectivity:* Objectivity involves the notion that science and math are the only legitimate ways of knowing, leading engineers to believe that STEM is devoid of political/social bias and that any people or groups looking at the same data will come to the same conclusions [12]. While natural processes act without political/social intent, people practice science within a social context that is immersed in cultures infused with political and social power differentials. The questions asked, priorities assigned, interpretation of data, and presentation of results are all deeply subjective. Conversely, SE respects and values varied ways of knowing and, therefore, the sharing of power over what and how engineers should research, design, and implement.

- *Meritocratic*: Meritocracy is the false assumption that the system as it currently exists is fair and just. The meritocratic narrative purports that equal reward is always provided by the system for equal effort within it and that the lack of success is correlated with lack of effort or worth [33]. The narrative of meritocracy is contrary to SE, because it sustains and perpetuates existing oppressive structures.

Other aspects of mainstream engineering education and professional culture that are less frequently critiqued:

- *Individualism*: There is limited systems thinking or consideration of societal level collective solutions in engineering - the responsibility, as well as the onus for change, is on the individual more than on the system. Individuals are blamed for lack of success or advancement despite facing systemic barriers. Individualism rejects SE notions of care, love, kinship, and relationship building while it masks and upholds oppressive structures.
- *Elitism*: Trends in engineering innovation are led by the small "elite" (white, wealthy) group that is employed in business and in research institutions and which serve similar "elite" groups. Thus, engineering design is not universal; the systems are either designed for or only accessible to elite groups. On the contrary, SE, in the spirit of universal kinship, focuses effort on including and addressing the needs of those (human and non-human) who have traditionally been left out.
- *Technocratic*: The focus is on innovation – big solutions to big problems – rather than democratic processes or relationships [34]; on applying a band-aid without addressing root causes of injury. For example, the Engineering Grand Challenges include 'Better Medicines' and 'Access to Clean Water' [35], but access to medicine and basic needs is not limited by technology, but by capitalism, racism, and/or imperialism. Engineering design processes do not currently prioritize social justice or human well-being, but SE offers a new way of thinking about the engineer's relationship to the community through care, love, kinship, and connectedness. SE recognizes that engineered technology is not always the solution that is required.
- *Privatizatization*: Private ownership of public necessities, budget cuts, and firing of staff have led to failing civil infrastructure. The focus is on efficiency without a useful purpose, because "value" is measured in terms of profit, and not in terms of social or human good. SE, instead, focuses on how we can create transformational change by collaborating together and sharing the "value" of enhanced human well-being and environmental flourishing that we generate
- *Extractivism*: Unsustainable practices prioritize wealth accumulation, not the well-being of people or other living beings. SE recognizes our interconnectedness with one another and the Earth. In line with an SE framework, we aim to redirect engineering practice to empower marginalized communities who are most harmed by extractivist practices.
- *Glamour/Glitz*: Prioritization and valuation of robotics, machine learning, aerospace, drones, and other "smart" and "sexy" technology; overshadows and devalues branches of engineering that support basic human needs (water, sewer, transit, etc.). Much of the focus in engineering is on highly technical, often high-cost, innovations. Alternatively, SE works with communities to research or implement low-cost and/or low-tech engineering innovations aimed at improving wellbeing.

- *Saviorism*: Engineers are often portrayed as a "lone hero" or set of heroes who parachute in and develop profitable innovations or "solutions" for "lesser" communities, without engaging in authentic collaboration [36-37]. This is reflected in the framing of the National Academy of Engineering's Grand Challenges [35], many Kern Entrepreneurial Engineering Network (KEEN) activities [38], VentureWell [39], NSF I-Corps [40], and the celebration and glorification of capitalists such as Bill Gates and Elon Musk. Saviorism in the Global South frequently manifests as white saviorism, as exemplified by the work of Engineers Without Borders [41], missionary work, and many university service-learning projects. SE recognizes that there are no saviors. We each bring value to the community as we act together in kinship for transformational change.

Critique of Mainstream Approaches to Systemic Change

There are several existing models aimed at addressing inequalities in the field, but they typically fail to address the neoliberal roots in which the structure and culture of engineering has formed. Institutional "diversity, equity, and inclusion" (DEI) programming and initiatives only have as much power as the institution it is trying to change is willing to provide. Purely representational and neoliberal approaches, while perhaps resulting in increased diversity in hiring, leads to, for example, more diverse engineers making bombs, entrepreneurship and "corporate social responsibility" models that continue capitalistic oppression, and conversations about "ethical" militarism. These approaches fail to offer any challenge to fundamentally oppressive engineering systems.

At its core, our framework is not to derive an approach for "correcting" a flawed existing system, but rather to promote the deconstruction of a fundamentally oppressive existing system. Webb [42] argues that the university is "a corrupt and criminal institution complicit in patriarchal, colonial and racist systems and processes; a criminal institution comparable to the police as a racialized, gendered and class-based force of authority, surveillance, enforcement and enactments of everyday patterns of structural violence," [p. 97] and that efforts of dissent in this system such as radical courses, gatherings of the undercommons, and occupations provide only fleeting, transitory experiences of what we desire. Similarly, Ebony McGee, an anti-racist STEM education researcher and author, compares the system of STEM education to a standing exclusionary table. She explains that she doesn't want to bring other voices to the table – she wants to break the table [43]. *So how do we break the table, and what does a new table look like?* This is the process we refer to as "re-engineering engineering".

Methodology

We approach our work through the methodology of Collaborative Inquiry (also known as Co-operative Inquiry), an iterative process in which those engaged share knowledge and experiences, reflect on the interplay of each others' perspectives, and work to synthesize these ideas into a deeper understanding of the inquiry for the purpose of taking action [44]. Employing Collaborative Inquiry, we acted as both researchers and subjects and sought to develop and act on strategies for transformative change, embodying these strategies in our work together. Additionally, as we endeavor to critique and "re-engineer" engineering through the framework of SE, our approach to collaborative inquiry is itself grounded in the premises of SE. We are not

simply academic colleagues doing professional tasks together; we strive to be a community based in respect, care, appreciation, and love for one another, a manifestation of SE in action.

We have met once a week via Zoom since early October, 2022. These meetings were scheduled for one hour but in practice often lasted an hour-and-a-half to two hours. We also maintained communication and built community through a WhatsApp group chat outside of our meetings. In our Zoom meetings and group chat, we engaged in practices aimed at creating community through dialogue. We intentionally placed a strong focus on relationship building. Consequently, each meeting began with sharing of our individual joys and struggles, during which we were able to provide support for one another in the form of love, encouragement, and acts of solidarity. After dedicating valuable time to building community, we engaged in the collaborative inquiry process of reflecting on our personal stories, our values, and our challenges with the current system of mainstream engineering.

Instead of starting with an examination and critique of the existing systems in engineering, we began sharing personal stories from our educational experiences and professional lives. We collectively reflected on these stories and used them to envision the new kind of engineering we desire. This application of the collaborative inquiry process was in alignment with the liberatory pedagogy of the Highlander Research and Education Center (the popular education center founded by Horton) detailed in their "Methodologies en Color" brochure [22]: *"Start with participant experiences, look for patterns between those experiences that can highlight shared struggle, add new information/theory, practice skills, strategize and plan, take action to change the world, reflect, and return to the beginning of the spiral!"* [p. 1].

To help facilitate this process, we borrowed from the "Deepen" experience utilized in the Remaking Education event hosted by Olin College of Engineering and Emerson College which Sarah had attended in Boston in 2018 [45]. We shared stories of impactful experiences from both elementary school and our engineering educations and then identified the key underlying beliefs or values revealed by each story. As each researcher-participant shared their story, Sarah took detailed notes on a Google JamBoard, and when it was Sarah's turn to share, Corey (Corin) took on the note-taker role. In a member-checking mechanism, each researcher-participant looked over the Jam Board after sharing to confirm the accuracy of the notes, address any discrepancies, and add any details that might have been missed.

As we move forward in our process of collaborative inquiry, we will identify values that are common across multiple stories or that resonate strongly with the group, which will then be used to create themes. Moreover, as we come together to share, write, reflect, research, and dream, we engage in constitutive rhetoric, which has served to build a sense of solidarity in our group. In our development of this work, we strove to model and implement a community of care as a prototype for a "re-engineered" system of engineering.

Preliminary Results and Discussion

The process of sharing individual stories of our formative education experiences, both positive and negative, was a key piece of building a solidarity-focused community within our authorship group. As our backgrounds and positionality vary significantly, our stories were notably diverse, and the process was impactful to us individually and collectively.

For example, one of our group members shared the following story of a harsh educational experience in the sixth grade. The experience left her with unresolved feelings as to whether the experience was "healthy." But, the overriding sentiment was that of resisting oppression:

> *The sixth grade was an unforgettable time for me. I learned very early that the bar was set high for little brown skin girls in the Caribbean and striving for the top was paramount to my success. Raised by a single mother who had the highest expectations of me, there was no room to fail or slip up or let down the sides. In the classroom, my teacher, Mrs. L had her own unique way of ensuring we never let our parents down. As we prepared for what seemed like the biggest examination of our life, she conditioned us to recognize patterns on past papers, to work efficiently within time constraints and to compete against our classmates for the very limited seats available in the best high schools on the island. I can't tell you if it was 'healthy' competition or not, but it carved a hunger in me to be the best, want the best and have the best, but surprisingly, it created something far greater. One of Mrs. L's unique methods of motivation was to put us in a high stakes environment where we ran exam "marathons", where her students would come in first thing at 7 in the morning, speak with no one, focus, start an exam until we completed 7 papers in the subject of the day. At the last hour of school, she would grade all papers, tallie the scores and rank the entire class from best to worst test score averages. After we received our rank, we repeated the process the following day, another rigorous eight hours of exams. The second ranking would be posted on the board for all to see. Then, she would take the difference between the two grades. This number meant everything to us, because this number meant the number of beatings we would get from 'The Rod', her infamously named wooden stick. If you got 94% on your first exam and 88% on the second, that's 6 lashes for the day. I had no choice but to succeed, to push beyond myself or else… To push beyond the self was how the whole class survived the grueling experience. We took it for sport to get punished together. We made it humorous, light hearted, laughed through it, cried through it, stood together, but most importantly, studied together, because we wanted no one to have any lashes by the end of the week. It made us excel, but more so, it made us care. Solidarity is the heart of my survivorship of oppressive education systems. Standing together against a system forcing us to compete for knowledge, resources and acknowledgement, solidarity is the greatest act of resistance.*

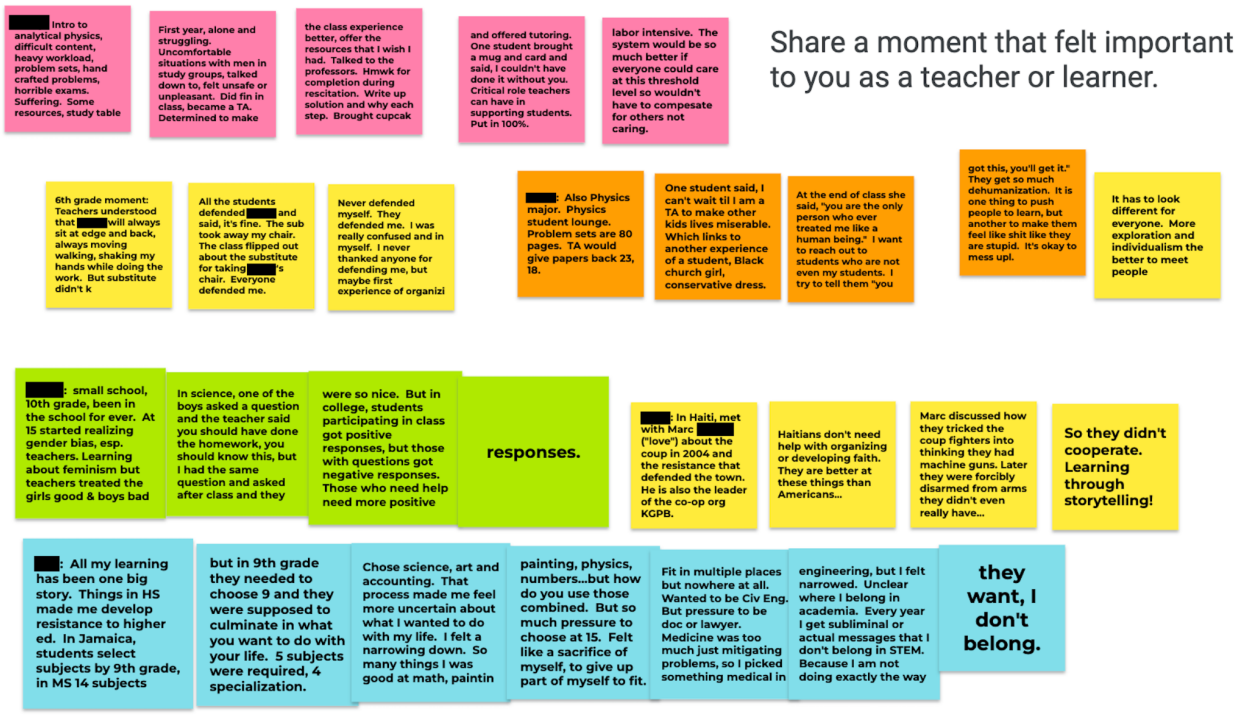
In contrast, one of us shared an experience of liberation and creating transformative change by spreading love as a six-year-old:

> *I moved very frequently in the first few years of my life, as my parents' jobs weren't stable. When I was in the first grade, we moved to rural Michigan. In my new school, I did not fit in at all. I had no idea how to fit in with aggressive students whose families had lived here for generations, and I was picked on a lot. I made one friend, Ellie. She was the toughest person I have ever met. She had pet rats that crawled on her. Everything she did was planned and calculated. As a*

> *first-grader, she was already doing the work of analyzing education systems, deciding how things should be, and doing it. And I tagged along. She was teaching me how to have meta conversations about systems when we were six years old. Ellie decided that the most important part of the school day was to go "hugging", instead of whatever we were supposed to be doing for the first half-hour of the school day. So every day, we simply walked out of the classroom to "go hugging." We weren't prioritizing visiting admin or teachers, but all the support staff. I remember how happy they were to see us each day and them talking about why this made a difference to them. Ellie decided that this is what the education system should look like, and she just did it.*

Each of us shared at least two stories, one from our K-12 experience and one related to our teaching and learning experiences. We collected notes from our stories on post-its on Google Jamboard Slides. An example of this is provided in Figure 1.

Figure 1: An example of one slide in which we collected some of our stories

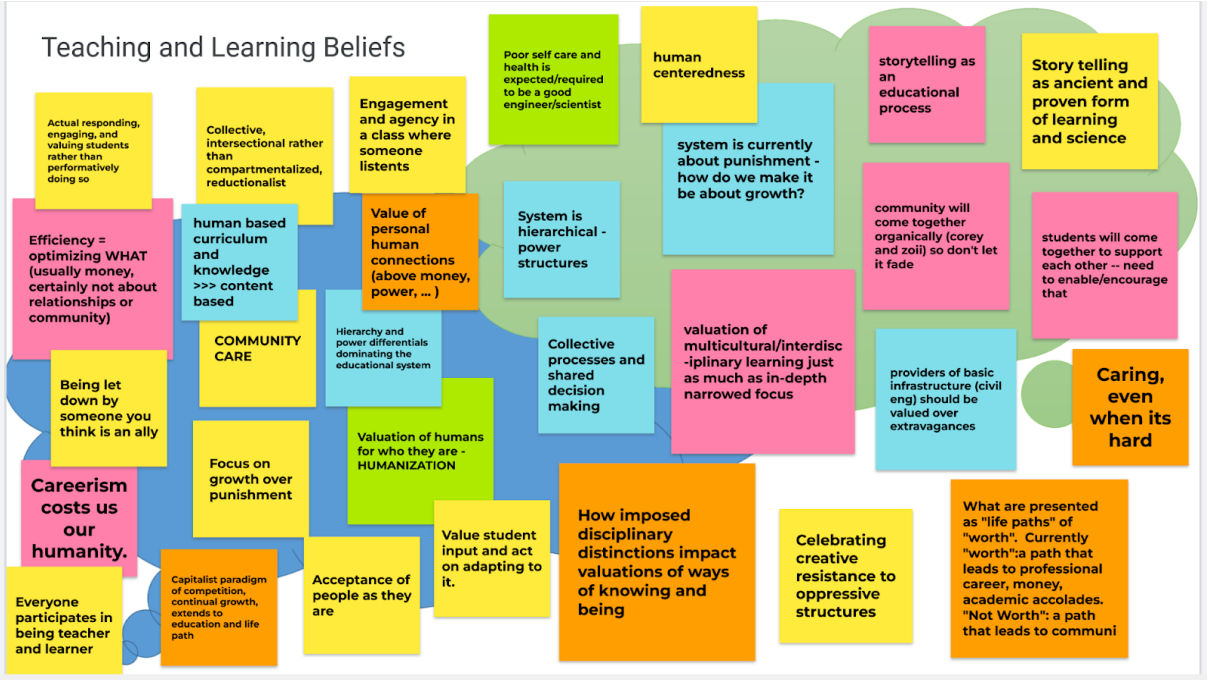


Our stories illustrate our progress both unpacking our educational experiences as well as "re-engineering" foci of what we believe a solidarity-focused system of engineering education might look like. From the two stories we highlighted, we are gaining insight into some of what we find problematic - a punitive approach to teaching and learning - and potential pathways to a better system - a focus on bonding, joy, and support.

Next, we analyzed the stories of our lived experiences, together extracting common beliefs about teaching and learning that we consider essential for human growth and education. An in-progress

slide, shown in Figure 2, illustrates some of the important common beliefs we identified from across the many stories we shared.

Figure 2: Our common beliefs about teaching and learning



As can be seen in Figure 2, the collective beliefs we extracted from our stories resist the structures and systems that we experienced in our own pathways and rejected. They also establish new goals and dreams for engineering education. We believe these collective beliefs reflect a more humanizing vision of an educational system that was derived from a humanizing experience and community we built together. However, our viewpoints are also a distinct result of our positionalities. It raises further questions– How can masses of people lacking structural power gain agency in the intentional construction of educational systems? How do we build communities that provide the space and agency for that work to take place? What could the result of that work even look like?

Future Work and Implications

> **"Colonialism is a plague, capitalism is pandemic.**
>
> These systems are anti-life, they will not be compelled to cure themselves.
> We will not allow these corrupted sickened systems to recuperate.
> We will spread.
>
> **We are the antibodies."** [46]

We are in the process of conducting a deeper analysis of all our stories to identify common themes, to explore how these themes align with existing theories, and to map our results with the work of other groups who are already addressing education in liberatory ways. We recognize that new ways of thinking and being will likely come from outside the academy and not from within it [42]. Already, we have found commonality with and taken inspiration from education and research exemplars such as the Zapatista movement's Escuelas Populares [47], the Science Shop movement [48], Highlander Education and Research Center [21], and the Civic Laboratory for Environmental Action Research (CLEAR) [49]. Our goal is to define a set of practices, based on the methods of these and other successful experiences, in order to help us manifest SE in the world. As we share our stories, support one another through our weekly trials and triumphs, and participate in our own liberatory praxis, we become community to one another. We start to live out SE and implement Pedagogies of Love in our small Zoom space. As we do so, we make real its methods and become its champions.

We hope that this paper will spark larger conversations about how the field of engineering can reframe its ways of engaging within the world to move toward Solidarity Engineering and begin to contribute to an ethic of care, love, equity, and justice among people and planet.

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